Dr. Jen Practice Exam #2 Key

1) Highest concentration of Cl^- ions: (d)

$$\frac{1.25\ mol\ AlCl_3}{L\ sol'n} \times \frac{3\ mol\ Cl^-}{1\ mol\ AlCl_3} = 3.75\ M\ Cl^-$$

$$\frac{3.0\ mol\ HCl}{L\ sol'n} \times \frac{1\ mol\ Cl^-}{1\ mol\ HCl} = 3.0\ M\ Cl^-$$

•Shortcut: M x # of Cl (subscript)

$$\frac{1.0\ mol\ CaCl_2}{L\ sol'n} \times \frac{2\ mol\ Cl^-}{1\ mol\ CaCl_2} = 2.0\ M\ Cl^-$$

$$\frac{2.0\ mol\ MgCl_2}{L\ sol'n} \times \frac{2\ mol\ Cl^-}{1\ mol\ MgCl_2} = 4.0\ M\ Cl^-$$

2) Oxidation #s of each element in $Na_3Co(NO_2)_6$: (b)

$Na_3[Co(NO_2)_6]$

$[Na^{+1}]\ [Co(NO_2)_6]^{3-}$

Co^{+3} — $Co\ \ NO_2^-$ ← know from polyatomic ions so can determine Co

$+3\ \ -1$

$\times 1\ \ \times 6$

$+3\ \ -6 = -3$

N^{+3}, O^{-2} — NO_2^-

$+3\ \ -2$

$\times 1\ \ \times 2$

$+3 + -4 = -1$

Alternatively,

$(1 N) + (2 O) = -1$ (know O)

$x + (2 \times -2) = -1$

$x - 4 = -1$

$+4\ \ +4$

$x = +3$ so N^{+3}

Alternatively,

$[(1)(Co)] + [(6)(NO_2)] = -3$ (don't know; know charge = -1)

$x + 6(-1) = -3$

$x - 6 = -3$

$+6\ \ +6$

$x = +3$ so Co^{+3}

•Shortcut:

eliminate obvious incorrect then do ↗

For example, Na^{+2} ← can never be so (a) is incorrect

O° ← can't be if it's in a compound so (d) is incorrect

3) ΔE of system: (C)

absorbs $+2{,}500.\text{J} = q$

does $-7{,}655\text{ J} = w$ on surroundings

$\Delta E = q + w$

$\Delta E = (2{,}500.\text{J}) + (-7{,}655\text{J})$

$= -5155\text{ J}$

4) V added to dilute a sol'n: (C)

initial: $V_1 = 15.0\text{mL}$ final: $m_2 = 0.025\text{m}$

$m_1 = 0.200\text{m}$

$m_1V_1 = m_2V_2$

$V_2 = \frac{m_1V_1}{m_2} = \frac{(0.200\text{m})(15.0\text{mL})}{(0.025\text{m})} = 120.\text{mL}$ total needed so

$120.\text{mL} - 15.0\text{mL} = 105\text{mL}$ need to be added

5) Apply Hess's Law to determine ΔH_{rxn}: (b)

Desired rxn: $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

Given: $2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = -790\text{ kJ}$

~~$S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta H = -297\text{kJ}$~~

need to reverse → change sign

need multiple = 2 → multiply by 2

$2SO_2(g) \rightarrow 2S(s) + 2O_2(g)$ $\Delta H = +594\text{ kJ}$

$2SO_2(g) + O_2(g) \rightarrow 2SO_3$ $\Delta H = (-790\text{kJ}) + (594\text{kJ})$

$= -196\text{kJ}$

6) Enthalpy Stoichiometry: (b)

$2MgO(s) \rightarrow 2Mg(s) + O_2(g)$ $\Delta H_{rxn} = +602\text{kJ}$

ΔH_{rxn} for 1.234 moles?

$1.234\text{ moles MgO} \times \frac{602\text{kJ}}{2\text{ mol MgO}} = 371\text{kJ}$

7) Selective precipitation (application of solubility rules): (a)

- Strategy: Pair anion with these cations & see which pdts are soluble or not.

$NaCl \rightarrow AgCl(s)$, $MgCl_2(aq)$, $SrCl_2(aq)$ *

$NaOH \rightarrow AgOH(s)$, $Mg(OH)_2(s)$, $Sr(OH)_2(aq)$

$Na_2SO_4 \rightarrow Ag_2SO_4(s)$, $MgSO_4(aq)$, $SrSO_4$ (s)

$Na_3PO_4 \rightarrow Ag_3PO_4(s)$, $Mg_3(PO_4)_2(s)$, $Sr_3(PO_4)_2(s)$

8) Use ΔH_f° to determine ΔH_{rxn}°: (a)

$2\,CO(g) + O_2(g) \rightarrow 2\,CO_2(g)$ $\quad \Delta H_{rxn}^\circ = \sum \Delta H_f^\circ$ pdts $- \sum \Delta H_f^\circ$ reactants

$(-110.5\,kJ/mol)$ $\quad$ $(-393.7\,kJ/mol)$

O_2: element instd. state $\therefore \Delta H_f^\circ = 0$

$$\Delta H_{rxn}^\circ = \left(2\,mol \times \frac{-393.7\,kJ}{mol}\right) - \left(2\,mol \times \frac{-110.5\,kJ}{mol}\right) = -566.4\,kJ$$

9) Production of 0.4 M NaCl soln: (b)

a) $NaOH + HCl \rightarrow NaCl + H_2O$

$V = 500\,mL$ $\quad V = 500\,mL$

$M = 0.4\,M$ $\quad M = 0.4\,M$

same, so neither limiting so just calculate 1

$$500.0\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.40\,mol}{L} \times \frac{1\,mol\,NaCl}{1\,mol\,HCl}$$

$$\frac{0.2\,mol\,NaCl}{1\,L} = 0.2\,M\,NaCl$$

$500\,mL + 500\,mL = 1{,}000\,mL = 1\,L$

b) $V = 300\,mL$ $\quad V = 600\,mL$

$M = 1.2\,M$ $\quad M = 0.6\,M$

$$300\,mL \times \frac{1\,L}{1000\,mL} \times \frac{1.2\,mol\,NaOH}{L} \times \frac{1\,mol\,NaCl}{1\,mol\,NaOH} \times \frac{}{\left(300\,mL + 600\,mL \times \frac{1\,L}{1000\,mL}\right)} = 0.4\,M\,NaCl$$

c) $NaCl$

$V = 500\,mL$ $\quad + 500\,mL\,H_2O$ $\quad M_1V_1 = M_2V_2$

$M = \frac{0.40\,mol}{L}$ $\quad$ ↑ this will dilute it to be a lower molarity

10) Determine C_s

(b)

$m = 8.29\,g$ absorbs $q = +50.3\,J$

$T_f = 28.5°C$, $T_i = 21.1°C$

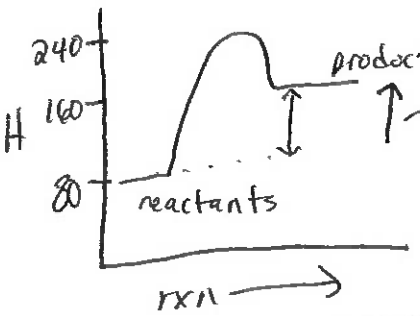
$\Delta T = 7.4°C$

$q = m C_s \Delta T$

$50.3\,J = q = (8.29\,g)\,C_s\,(28.5°C - 21.1°C)$

$C_s = \frac{q}{m\Delta T} = \frac{50.3\,J}{(8.29\,g)(7.4°C)} = 0.82\,J/g\cdot°C$

11)



gain enthalpy (positive H) ∴ endothermic

$\Delta H_{rxn} = H_{products} - H_{reactants} = 160\,kJ - 80\,kJ = +80\,kJ$

12) $3\,Ba(OH)_2(aq) + 2\,H_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + 6\,H_2O(l)$

want $\frac{\Delta H_{rxn}\,(kJ)}{mol\ H_2O}$

$V = 55.0\,mL$, $M = \frac{0.370\,mol}{L}$

$V = 45.0\,mL$, $M = \frac{0.435\,mol}{L}$

soln + rxn

$\Delta T = 26.21 - 23.01°C = 3.20°C$ ← soln is getting hotter ∴ rxn must be releasing heat (exothermic)

$d = 1.00\,g/mL$

$C_s = \frac{4.184\,J}{g\cdot°C}$

$q_{soln} = m_{soln}\,C_{s\,soln}\,\Delta T_{soln}$ (solve for)

↳ m_{soln} = mass $Ba(OH)_2$ soln + mass H_3PO_4 soln

$55.0\,mL \times \frac{1.00\,g}{mL} = 55.0\,g$

$45.0\,mL \times \frac{1.00\,g}{mL} = 45.0\,g$

$> 100.0\,g$ total soln

$q_{soln} = (100.0\,g)\left(\frac{4.184\,J}{g\cdot°C}\right)(3.20°C) = 1338.88\,J \times \frac{1\,kJ}{1000\,J}$

$q_{soln} = 1.338\,kJ$

so $q_{rxn} = -1.338\,kJ$

$55.0\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.370\,mol}{L} \times \frac{6\,mol\,H_2O}{3\,mol\,Ba(OH)_2} = 0.407\,mol\,H_2O$ *limiting*

$45.0\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.435\,mol}{L} \times \frac{6\,mol\,H_2O}{2\,mol\,H_3PO_4} = 0.0587\,mol\,H_2O$

Recall, $\Delta H_{rxn} = q_{rxn}$ at constant pressure (in a calorimeter)

$\frac{\Delta H_{rxn}}{mol\ H_2O} = \frac{-1.338\,kJ}{0.407\,mol\,H_2O} = \boxed{-32.9\ kJ/mol\ H_2O}$

13) $2\,LiOH(aq) + H_2SO_4(aq) \rightarrow Li_2SO_4(aq) + 2H_2O(l)$

$V = 0.800\,L$ $\quad M = \frac{0.290\,mol}{L}$ $\qquad V = 0.850\,L$ $\quad M = \frac{0.400\,mol}{L}$

(a.) Lithium hydroxide, ~~sulfuric~~ sulfuric acid, lithium sulfate

(b.) Acid-base (neutralization)

(c.) want M excess reactant at end of rxn

① Determine which is in excess:

	Have	Need
LiOH	0.232	0.680
H_2SO_4	0.340	0.116 *excess*

$0.800\,L \times \frac{0.290\,mol}{L} \times \frac{1\,mol\,H_2SO_4}{2\,mol\,LiOH} = 0.116\,mol\,H_2SO_4$ (0.232 mol LiOH)

$0.850\,L \times \frac{0.400\,mol}{L} \times \frac{2\,mol\,LiOH}{1\,mol\,H_2SO_4} = 0.680\,mol\,LiOH$ ($0.340\,mol\,H_2SO_4$)

② Determine moles remaining:

$moles_{remaining} = moles_{start\,w/} - moles_{consumed}$

$= 0.340\,mol\,H_2SO_4 - 0.116\,moles\,H_2SO_4 = 0.224\,mol\,H_2SO_4$ remain

③ Determine $V_{sol'n}$:

$V_{sol'n} = V_{LiOH} + V_{H_2SO_4} = (0.800\,L + 0.850\,L) = 1.65\,L$

④ Determine M:

$M = \frac{moles\,H_2SO_4}{L_{sol'n}} = \frac{0.224\,mol\,H_2SO_4}{1.65\,L} = \boxed{0.136\,M\,H_2SO_4}$

14) $2\,Al(s) + 3\,Co^{+2}(NO_3)_2(aq) \rightarrow 2\,Al(NO_3)_3(aq) + 3\,Co^{0}(s)$

(Al: 0 → +3, lost 2e⁻s; Co: +2 → 0, gained 2e⁻s)

$m = 0.153\,g$ $\qquad M = \frac{0.235\,mol}{L}$

$V = 50.0\,mL$

limiting (all is consumed)

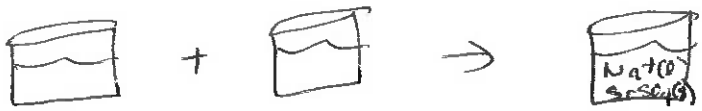
(a.) want grams of Co(s)

$50.0\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.235\,mol}{L} \times \frac{3\,mol\,Co}{3\,mol\,Co(NO_3)_2} \times \frac{58.933200\,g}{mol} = \boxed{0.692\,g\,Co}$

(b.) oxidized (lose e⁻s): Al

oxidizing agent (causes oxidation, is itself reduced): $Co(NO_3)_2$

15)



$Na^+ Cl^-$ $Sr^{2+} SO_4^{2-}$

resulting = pdts

(a.) Molecolar eq.

$$Na_2SO_4(aq) + SrCl_2(aq) \longrightarrow 2\,NaCl(aq) + SrSO_4(s)$$

↖ doesn't breakup

(b.) Complete ionic eq. (all aq sol'n break into ions)

$$2\,Na^+(aq) + SO_4^{2-}(aq) + Sr^{2+}(aq) + 2Cl^-(aq) \rightarrow 2\,Na^+(aq) + 2Cl^-(aq) + SrSO_4(s)$$

(c.) Spectator ions

Na^+ & Cl^-

(d.) Net ionic eq.

$$SO_4^{2-}(aq) + Sr^{2+}(aq) \rightarrow SrSO_4(s)$$

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16)

$$NaOH(aq) + HNO_3(aq) \longrightarrow NaNO_3(aq) + H_2O(l)$$

$m = 17.5\,g$

$V = 350\,mL$

$V = ?$

$M = \frac{0.250\,mol}{L}$

$$17.5\,g \times \frac{mol\ NaOH}{39.997\,g} \times \frac{1\,mol\ HNO_3}{1\,mol\ NaOH} = 0.4375\,mol\ HNO_3$$

$$0.4375\,mol\ HNO_3 \times \frac{L}{0.250\,mol} = \boxed{1.75\,L\ HNO_3}$$